Accelerator Physics Software Development

N. Malitsky, A. Shishlo

November 1, 2000

Acknowledgements

BNL: J. Beebe-Wang, A.Fedotov, Y.Papaphilippou, D.Raparia, S. Sathe, J. Smith, J.Wei, J. Weng

ORNL: J. Galambos, J.Holmes

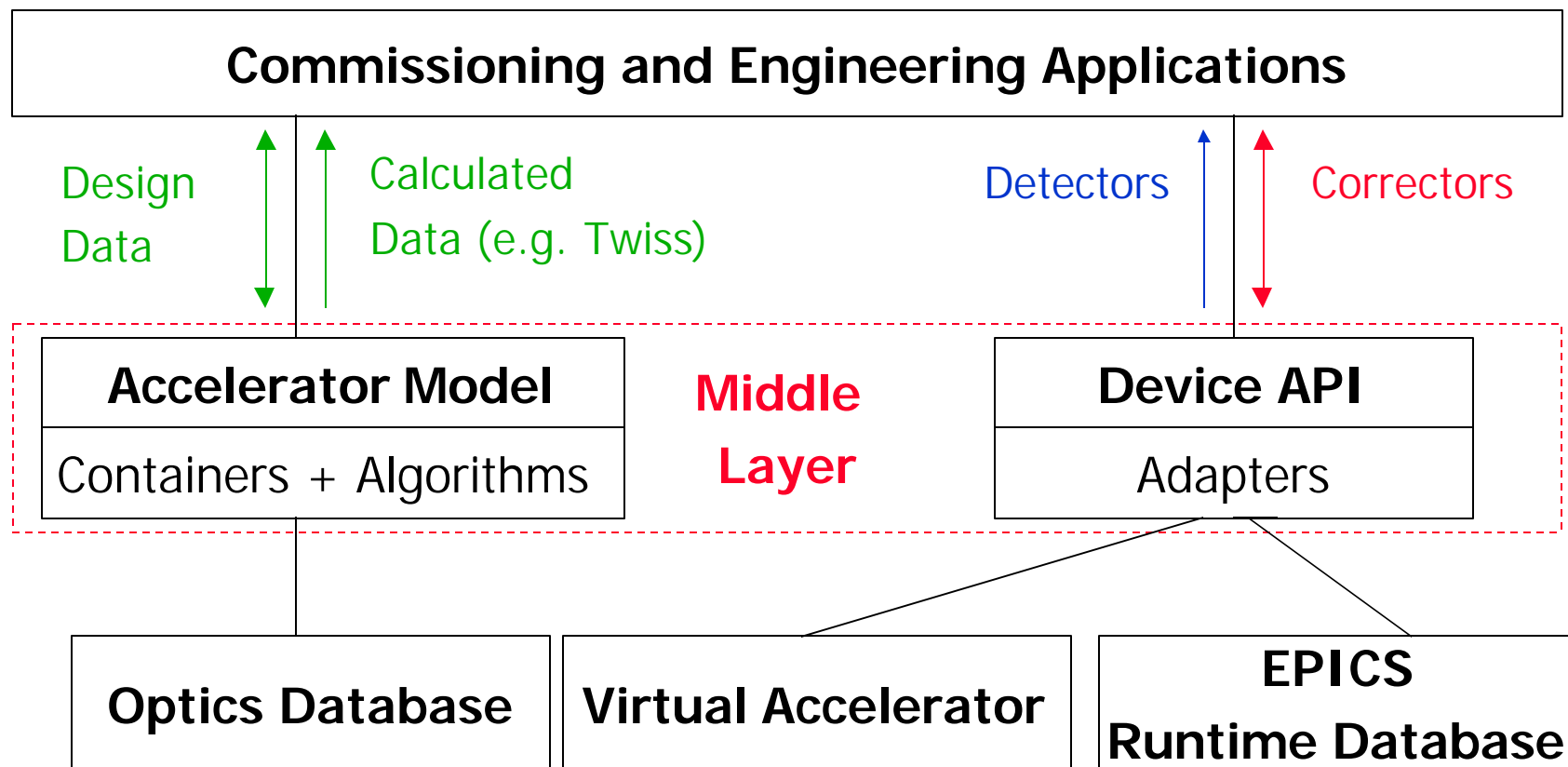# Progress in the Accelerator Physics Software Development

- **Ring off-line simulation environment**
  - the SNS package has been developed for simulating the Ring multi-turn injection in the presence of several physical effects, such as space charge, field errors, misalignments, and fringe fields;
  - four unified accelerator libraries (such as PAC, TEAPOT, ZLIB, and ALE) have been installed on the BNL parallel cluster for Ring dynamic aperture studies.

- **infrastructure for Ring control applications**
  - developed the prototype of the Ring Optics Database;
  - implemented a Java tool for exchanging the accelerator lattice description between the Optics Database tables and the ADXF (Accelerator Description eXchange Format) files.

SNS Ring Off-line Simulation Codes

	UAL (sun)	UAL (cluster)	FTPOT	MAD 8	MARYLIE 3.0	ACCSIM	ORBIT
Interface	PERL API	PERL API	FTPOT	MAD	MARYLIE	ACCSIM	SuperCode
MAD elements	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Errors	Yes	Yes	Yes	Yes	No	No	No
Tracking	Thin lenses	Thin lenses	Thin lenses	Lie algebra	Lie algebra	Linear matrices + nodes	Linear matrices + nodes
Mapping	Any order	Any order	Second order	Third order	Third order	Linear order	Linear order
Painting	Yes	No	No	No	No	Yes	Yes
3D Fringe Field	Yes (via Map)	Yes (via Map)	No	No	Yes	No	No
Space Charge	2.5D	No	No	No	No	2.5D	2.5D
Analysis (Twiss, …)	Yes	Yes	Yes	Yes	Yes	No	No
Lattice Optimization	No	No	No	Yes	Yes	No	No
Correction (Orbit, …)	Yes	Yes	Yes	Yes	Some	No	No
Integration of several lattices	Yes	Yes	No	No	No	No	No

Conceptual Design of the Ring Control Application Environment

Commissioning and Engineering Applications

Design Data

Calculated Data (e.g. Twiss)

Detectors

Correctors

Accelerator Model

Containers + Algorithms

Middle Layer

Device API

Adapters

Optics Database

Virtual Accelerator

EPICS Runtime Database

Model-Based Control Systems

- **SLS, PSI** M.Boge, J.Chrin, M.Munoz, A.Streun. *"Development of Beam Dynamics Applications within a CORBA Framework at the SLS"*, EPAC 2000.

- **RHIC, BNL** Satogata, K.Brown, F.Pilat, A.Alai Tafti, S.Tepikian, J. van Zeijts. *"The RHIC/AGS Online Model Environment: Design and Overview"*, PAC 99.

- **KEKB, KEK** N.Yamamoto, *"Use of a Virtual Accelerator for a Development of an Accelerator Control System"*, PAC 97.

- **FNAL** J.A.Holt, A.Braun, L.Michelotti, M.Martens. *"Accelerator Physics Computing in a Control System Environment"*, CAP 96.

- **JLAB** B.A.Bowling, W.Akers, H.Shoaee, W.Watson, J.vanZejts, S.Witherspoon. *"Evaluation of a Server-Client Architecture for Accelerator Modeling and Simulation"*, CAP 96.

List of the Ring Applications
(J.Wei, J. Galambos)

Ring (continued)

- **Injection**
  - Orbit closure algorithm
  - HEBT-ring orbit matching algorithm
  - Run-time HEBT-ring optics matching

- **Beam Orbits and Correction (BPM)**
  - Turn-by-turn orbit report
  - Difference orbit, average orbit
  - Injection beam orbit monitoring
  - Local DC bump orbit correction
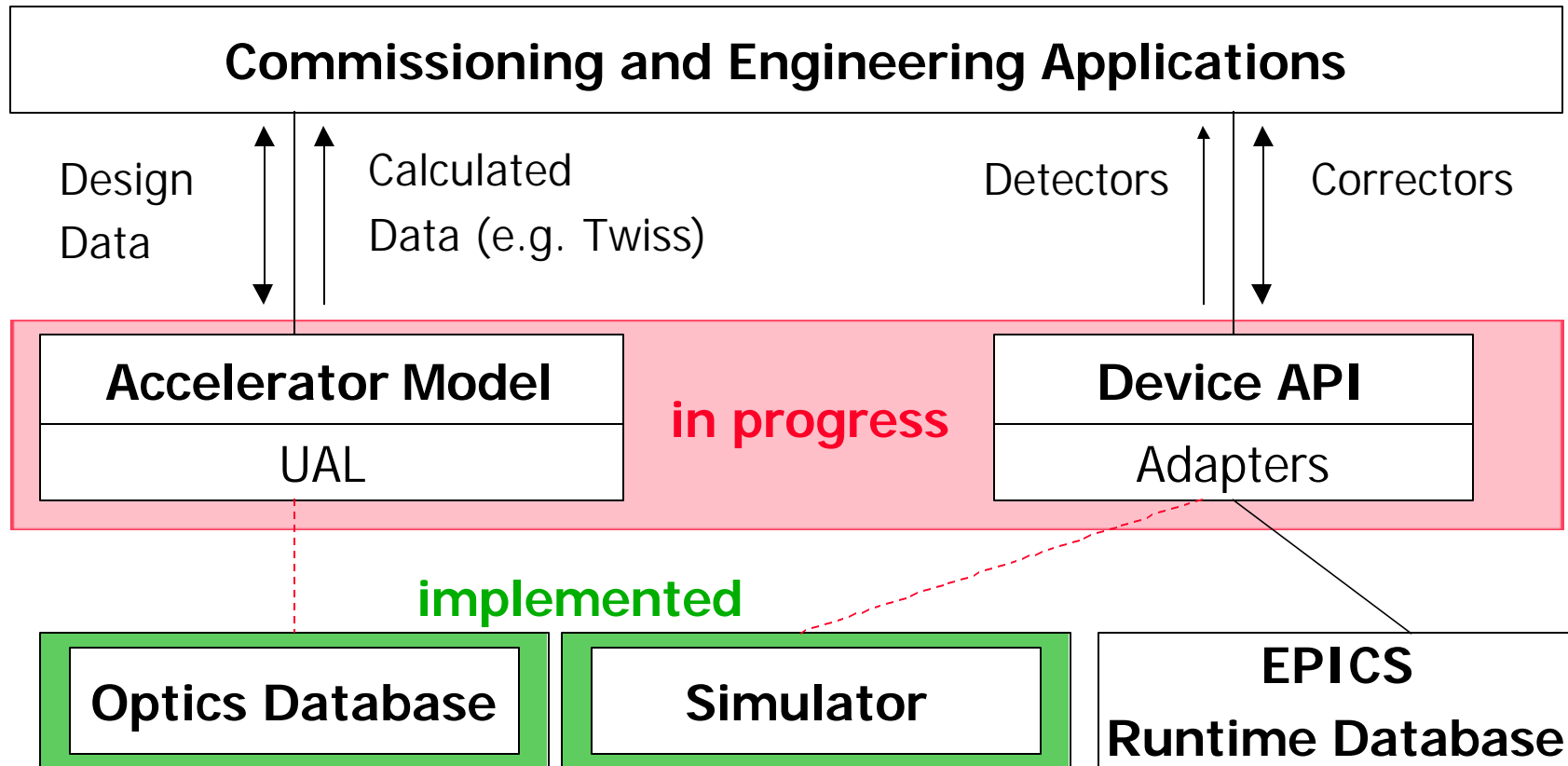 - Global orbit correction

Ring (continued)

- **Extraction**
  - Kicker voltage and timing adjustment
  - RTBT-ring orbit matching algorithm.

- **Simulations**
  - Transfer matrix, real machine vs. model
  - Painting
  - Beam tail and halo development (space charge, magnetic errors, misalignment)

Status of the Ring Control Application Environment

Commissioning and Engineering Applications

Design Data

Calculated Data (e.g. Twiss)

Detectors

Correctors

Accelerator Model

UAL

in progress

Device API

Adapters

implemented

Optics Database

Simulator

EPICS Runtime Database

Optics Database

| Table name	Content
AcceleratorSystems	names & versions of complex accelerator systems (HEBT + Ring)
Accelerators	accelerator names (HEBT, Ring, RTBT)
AcceleratorLattices	version names associated with different accelerator structures
AcceleratorStates	version names associated with different node structures
AcceleratorSources	version names associated with different data sources (actual, expected)
AcceleratorNodes	names & lengths of elements and assemblies of elements
AcceleratorNodeTypes	element types (sbend, quadrupole, rfcavity, etc.)
AcceleratorSequences	structure of assemblies and accelerators
AcceleratorNodeBuckets	structure of accelerator nodes
AcceleratorBucketTypes	bucket types (bend, mfield, rffield, alignment, aperture)
BendBuckets	bend attributes (horizontal and vertical angles)
MFieldBuckets	multipole harmonics (normal and skew components)
RFFieldBuckets	rf attributes (voltage, phase, etc.)
AlignmentBuckets	offsets and rotations of elements and assemblies
ApertureBuckets	aperture attributes (shape, horizontal and vertical sizes)

Interfaces Based on the Accelerator eXchange Description Format (ADXF) files.

Off-line Simulation Package

ADXF file

Optics Database

Online Accelerator Model
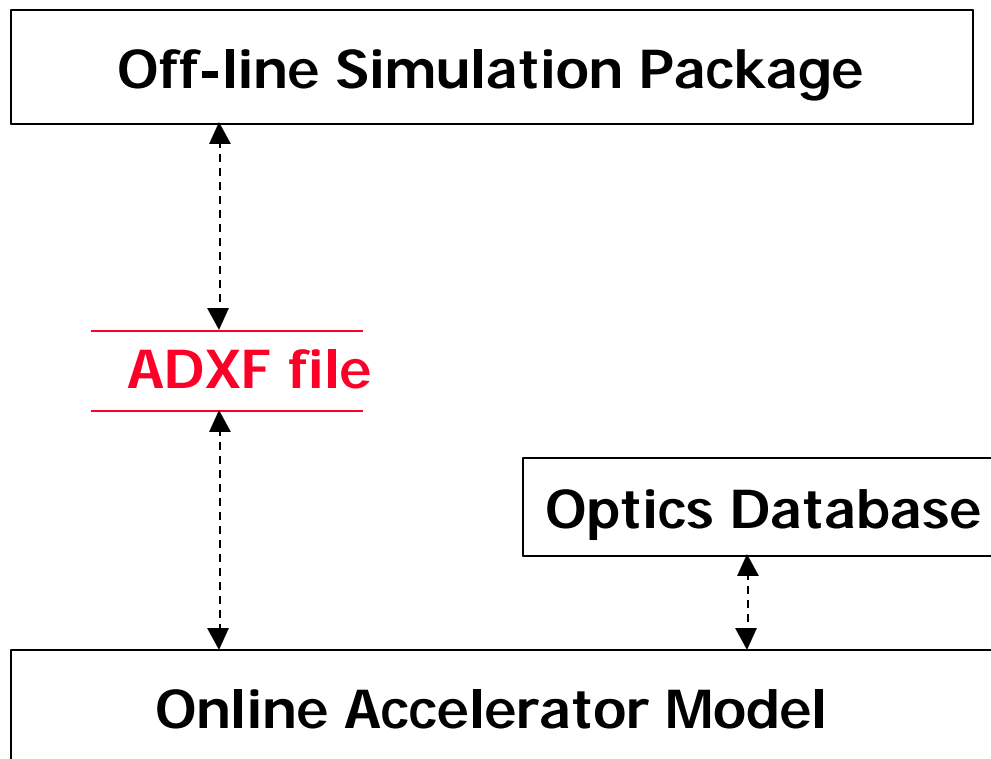
Applications:

- Initialization and test of the Optics database

- Integration of the off-line simulation package with the Optics database

- Interface between off-line and online environments

Editor for ADXF files
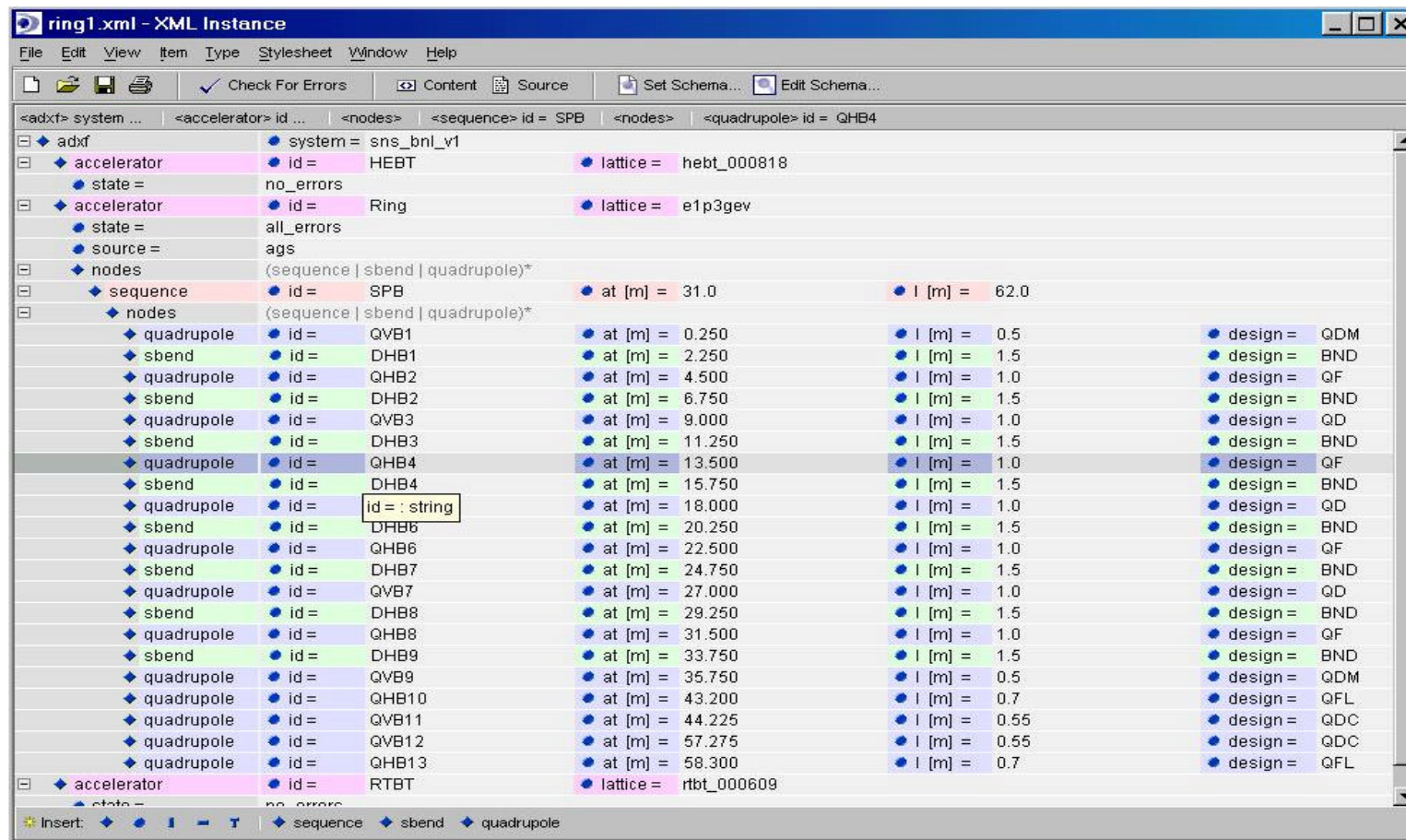
Summary

- space charge effects and element errors have been integrated in a single off-line simulation package;

- four unified accelerator libraries have been installed on the parallel cluster for dynamic aperture studies;

- prototype of the Optics Database has been implemented.

- Future activities:

  - installation of the ORBIT and ACCSIM libraries on the parallel cluster;

  - implementation of the ADXF-based interface between the off-line simulation environment and the Optics Database.

  - development of the online application server.